

**Stable Isotope Approach for Long-Term
Monitoring of Changes in Precipitation
Source Temperature and Sierra Nevada
Snowpack Runoff**

#0058

Technical Panel Review

Proposal Name: Stable Isotope Approach for Long-Term Monitoring of Changes in Precipitation Source Temperature and Sierra Nevada Snowpack Runoff

Applicant Organization: Lawrence Livermore National Laboratory

Principal Lead Investigator(s):

Davisson, M. Lee

Criss, Robert E.

Winston, William

Amount Requested: \$412,058

TSP Panel Summary of Findings:

Based on preliminary data, the team is confident that many daunting and complicating factors that determine isotope ratios in this system (factors that yield competing and variable fractionation of isotopes) can be taken into account and that their model will be sufficiently accurate for the purposes intended. The team is well chosen to carry out this work. It is a good proposal that proposes the generation of some data that might well lead to better management of reservoirs and stream flow in this system. The problem is that there are so many complicating factors related to snow melt and its isotopic composition that the project will almost certainly have to extend over a long period of time before a useful model and monitoring strategy is developed. This implies enthusiastic support of the key agencies, which is not apparent, and a sustained budget. The best solution, which might be possible, would seem to be to carry out the monitoring and data analysis part of the project to demonstrate the feasibility and advantages of the methodology and fund it through Washington University of St. Louis, where the lab and all of the model horsepower is located. It will be difficult to create a realistic predictive model based on the studies proposed here. The budget is modest for a very large sampling program plus model development and data analysis; however, the total would be a lot less if the project were funneled through W.U.S.L. instead of LLNL. One reviewer points

Technical Panel Review

this out, noting that "Of \$412,000, \$257,000 looks to be subcontracts. Yet, of the remaining \$155,000, \$96,000 is overhead. One item alone, the administrative oversight by the PI, is associated with overhead of 284%." There are no supporting letters from California or federal agencies that are required as partners if this project is to be successful (see external reviewer comment below).

Relevance to PSP Topic Areas:

Moderate

TSP Technical Rating:

Sufficient

TSP Funding Recommendation:

Do Not Fund

TSP Amount Recommended: \$0

Conditions:

External Technical Review #1

Proposal Title: Stable Isotope Approach for Long–Term Monitoring of Changes in Precipitation Source Temperature and Sierra Nevada Snowpack Runoff

Proposal Number: 0058

Proposal Applicant: Lawrence Livermore National Laboratory

Purpose

Comments	<p>The objective of this proposal is to conduct a large sampling campaign throughout the Sierra Nevada in order to analyze and create a large dataset of stable isotope from streamflow and snow pack. The sampling campaign will include samples from streams in various locations, various stages of the melt season, and in various time intervals. The study will provide information on the intra-annual isotopic signal as correspond with snow melt processes. It is also establishes a methodology and the basis for a long term creation of database that potentially reflect on the melt processes interannual variability and climate change impact. The study aim to develop quantitative relationships between the intra-annual isotopic signal in the streamflow to quantitative state of the melting processes upstream. This is an exciting proposal that initiate incorporation of isotope science in water resources management of snow-fed basins. It has a long term vision of establishing a routinely sampling scheme that will create valuable dataset for the characterization of the hydrologic cycle at a basin scale. This might be implemented as a tool for better use in the decision making processes.</p>
Rating	Superior

Background

Comments	<p>The authors provided a technical scientific background that refers to the various variables that control the isotopic signal in the streamflow and the snowpack. I got the impression that there was no previously done research on snow melt at the scale that is proposed. The researchers cite research which indicates that the onset of spring melt is correspond with minimum in heavy isotope content. They explained that the early melt is isotope depleted due to fractionation. That is, early in the melting cycle the liquid is in equilibrium with the frozen water in the snowpack. Later in the season the melt occur from all layer and the isotopic signal is approaching the mean of the snow pack. The EC however, later in the season goes through enrichment due to increase interaction of the melt water with the soil. This theory seems a little weak and subjective and I was not sure that I fully understood the seasonal fractionation. I think that a logic explanantion is missing. However I think that the data that will be collected will definitely help to strength the theory that explain the unique intra-annual isotopic signal. The researcher referred to a model that produce by Criss which is simple with one free parameter and reproduce the observed evolution of the isotopic signal.</p>
Rating	Above Average

Approach

Comments	<p>The study is a collaborative effort between LLNL and Washington University, MO The tasks are well diverse and build on the strength of the individual researches. The survey will rely on existing operational surveys. The proposes are confident that the approach is doable and with simple logistics (special water bottles that are collected) large samples can be mailed to a laboratory in Washington University. The analysis is quick, cheap and straight</p>
----------	--

External Technical Review #1

	forward. I am not familiar with isotopic analysis, but if it is indeed so simple, than this is a very promising approach that can initiate a routine long term sampling scheme that will provide interannual information for the snow melt processes. Some of the logistic is missing. Obviously the propose is a lositic operation with multiple agencies and lots of locations for sampling. An explanantio of the sampling logistic is missing, I understand that you can not enguge the agency before you have the funding, but maybe a best case scenario, a map with the sampling locations some distinctive properties of these locations and the temporal frequency of the sampling would have helped to grasp the spatial and temporal scale of the proposed project.
Rating	Above Average

Feasibility

Comments	The data collection seems feasible and if a routine sampling and creation of a large data set that last is the major outcome, I feel that the main goal has achieved.
Rating	Superior

Budget

Comments	The budget amount appear reasonable to me.
Rating	Superior

Relevance To CALFED

Comments	The creation of a basis for isotopic monitoring data base of two years might lead to a long lasting monitoring system. As far as I know there is no existence of such data base in such scale. This data base, is very valuable and in my opinion, such database will produce unexpected utilities in the future. It is definitely will provide a understanding for the hydrologic processes in the Sierra Nevada. The
----------	--

External Technical Review #1

	proposal fall in the first and third CALFED SPS: (1) Environmental Water; (3) Trends and Patterns of Populations and System Response to a Changing Environment. It advances the understanding of the complex environments/systems within the CALFED jurisdiction to aid policy-makers and resource managers. It is within the CALFED region.
Rating	Superior

Qualifications

Comments	The three investigators are experienced and well qualified. It appears that the spread of responsibilities is clear and the coordination amount the investigators are well thought.
Rating	Superior

Overall Evaluation Summary Rating

Comments	I recommend funding this proposal. The 2-year sampling campaign will create a unique database with basin scale perspective on melting processes. It will help identify isotopic signals in snow fed rivers that are related to melt processes and to source of precipitation. The researchers propose to conduct this study in large region, various basin properties and high frequency sampling. This will provide a set that have lots of information on the intra-annual processes in the Sierra Nevada. The creation of this database will involve on going operation sampling campaigns which reduce the cost and increase the awareness and educate operational staff regarding the value and significance of the use of stable isotope for water resources.
Rating	Superior

External Technical Review #2

Proposal Title: Stable Isotope Approach for Long–Term Monitoring of Changes in Precipitation Source Temperature and Sierra Nevada Snowpack Runoff

Proposal Number: 0058

Proposal Applicant: Lawrence Livermore National Laboratory

Purpose

Comments	The objectives and hypothesis are clearly stated and are internally consistent. The idea for investing time, effort and funding in this initiative is a good one. While timing is appropriate, the study as presented is more suited to a pilot or demonstration project than a full-scale implementation project, for reasons described later on in the review. Investment in this activity as described will increase the base of knowlege and generate new information, however caution should be noted that some anticipated outcomes may be difficult to achieve due to the state of existing knowledge and some caveats with experimental design.
Rating	Sufficient

Background

Comments	Citing previous studies, the proposal paints a fairly optimistic, and at times selective view of what might be accomplished in terms of tracking precipitation sources using isotope tracers. The conceptual model is described or alluded to in Figs. 1 through 4, and in the ensuing discussion which highlights the approach to be used with several examples. One notable omission is that the conceptual model of snowmelt does not include or at least does not describe assumptions
----------	--

regarding soil water, groundwater, frozen ground, or variability in these processes which may substantially influence the post-deposition/melt isotope signals in snowmelt runoff. The conceptual model does not adequately describe how the approach will distinguish between multiple controls on the isotope composition of snowpack and snowmelt in the downstream system including altitude of snowfall (Fig. 2), post-deposition metamorphism, evaporative enrichment, snowmelt fractionation, selective runoff, infiltration, degree of interaction with the existing groundwater/soilwater pool. The example in Fig. 4 shows evidence of early depletion in isotopic composition of runoff which precedes coincident peaks in electrical conductivity (EC) and stream discharge. The authors conclude that this is plainly evidence of snowmelt fractionation and expound on how they will use this in their planned study. An alternate explanation, which cannot be easily overruled is that peak snowmelt contributions occurred on the rising limb of the hydrograph, not at peak flow while the ground frost and snowpack itself formed somewhat of a barrier to infiltration. Perhaps then electrical conductivity and discharge peaked later on as snowmelt infiltration displaced water along deeper flowpaths and allowed greater chemical interaction with soils and groundwater. There is no doubt that measureable isotopic signals would be traceable in the downstream system, but the cause of these variations should be interpreted with some caution. The authors admit that there is incomplete knowledge of snowmelt physics and streamwater generation processes, and that evidence of properties

External Technical Review #2

	such as low-slope enrichment in Sierran snowpacks is probably rare.
Rating	Inadequate

Approach

Comments	<p>The work does not mention any plans to sample time-series of groundwater or soilwater during the melt period, only snowpack and river water. Groundwater and snow interaction in mountainous regions can be complex as both will have distinct altitude-dependent signatures. Springs may be localized conduits for water recharged at higher altitude. Mixing with snow at a range of altitudes may also difficult to model. The approach may be more successful if conducted either (i) at a hillslope or tributary scale to examine details of snowmelt process in one area and to unravel complexities of precipitation to discharge evolution, as a demonstration project, or (ii) at the broadest scale for basic identification of timing of snow contributions down the river network and at various regulation points. In the latter case it may be difficult or impossible to distinguish signals in snowmelt related to temperature effects, even after decades of sampling. Thirty years of isotope sampling in tributaries and precipitation in the Danube Basin of Europe (see "Isotope studies in large river basins: a new global research focus", EOS 83 (52) 24 December 2002, p.613, 616-617) has shown that the balance of Mediterranean/Northern European air mass trajectories was main reason for temporary shifts in isotope composition of river discharge in 1980s, erroneously attributed to global warming by some workers during the peak of the excursion.</p>
Rating	Inadequate

Feasibility

Comments	Due to the complexity and interplay of processes during precipitation to discharge transition, especially during snowmelt, it may be difficult to achieve many of the stated objectives. Feasibility of the study as presented should be reassessed after further pilot scale work is carried out to improve understanding of the snowmelt physical/isotopic phenomenon.
Rating	Inadequate

Budget

Comments	The budget is reasonable given the scope of work proposed.
Rating	Above Average

Relevance To CALFED

Comments	The proposal is relevant to the priorities stated in the PSP.
Rating	Sufficient

Qualifications

Comments	The track record of the authors is above average.
Rating	Above Average

Overall Evaluation Summary Rating

Comments	The proposal is somewhat oversimplified, promising more than it can deliver in terms of being able to unravel the underlying causes of isotope variations and linkages to climate change on a regional scale.
Rating	Inadequate

External Technical Review #3

Proposal Title: Stable Isotope Approach for Long–Term Monitoring of Changes in Precipitation Source Temperature and Sierra Nevada Snowpack Runoff

Proposal Number: 0058

Proposal Applicant: Lawrence Livermore National Laboratory

Purpose

Comments	Many of the ideas put forth in the proposal appear clear and justified (e.g., using stable isotopes to calibrate snow melt processes and model hydrologic forecasting). Clearly, there is a need to advance our ability to make reliable streamflow forecasts. The proposed methodology is appropriate for the outlined goals. Nonetheless, the long-term success of the project presupposes endorsement of the methodology by one or more entities, none of which is evident in the proposal. This is not a one-time project. For example, assessing climate-driven hydrologic changes would require a long-term commitment of resources to catalog alterations of isotopic signatures.
Rating	Above Average

Background

Comments	The conceptual model for the study is clearly articulated with the exception of how climate changes over time would be tracked. In fact, a lot of detailed technical information is presented in the proposal. Figures help illustrate specific aspects of the methodology and its application.
Rating	Above Average

Approach

Comments	The proposal is to be commended for identifying cooperators who would aid in collecting samples. Such an approach enlarges the number of rivers and sites that can be tested while keeping costs down. One person on the team is tasked with the sampling coordination. The plan for effective dissemination of results is the minimum that might be expected. No particular heed has been given to development of a database, or similar mechanism, for making data readily available to other interested parties.
Rating	Sufficient

Feasibility

Comments	<p>The project as described is likely to be successful. The proposers do note that one item of potential interest, "a detailed model that describes interannual variations in the amount and isotopic character of meteoric precipitation in the Sierra would be a noteworthy goal," may or may not be easily developed. It was difficult to discern from the proposal whether this was an integral aspect of the project or a nice addition should it be achieved.</p> <p>Given all the variables and complexities (i.e., non-equilibrium processes) that would ultimately play a role in the development of their model of isotopically-based runoff hydrology, some discussion of uncertainty relative to model predictions would have been helpful. One gets the sense from reading the proposal that there will be constant tweaking of the models to fit new data. Hence, is it possible to develop a method and have it be useful over a long period of time, or would long-term implementation of the approach laid out in the proposal require continual updating of the method? If the latter, the long-term successful adoption of the approach might be</p>
----------	---

External Technical Review #3

	questionnable.
Rating	Sufficient

Budget

Comments	The budget is incredibly hard to decipher. Of \$412,000, \$257,000 looks to be subcontracts. Yet, of the remaining \$155,000, \$96,000 is overhead. One item alone, the administrative oversight by the PI, is associated with overhead of 284%.
Rating	Inadequate

Relevance To CALFED

Comments	The stated justification is rather mediocre. The project may assist CALFED in managing water resources, but only for the length of the project. The secondary justification listed with the proposal information, "Trends and Patterns of Populations and System Response to a Changing Environment" is not discussed at all within the proposal. Other priorities listed in the PSP are not addressed.
Rating	Inadequate

Qualifications

Comments	The authors appear to have the necessary track record and resources to execute the project.
Rating	Superior

Overall Evaluation Summary Rating

Comments	While the proposal encompasses a sound methodology and applies it to a "real-world" problem, the authors have not given sufficient attention to the long-term success of their proposed approach. Given the proposed budget of the project, I would have misgivings about investing this large a sum in a project that
----------	--

External Technical Review #3

	might be no more than a one-time endeavor. The proposal does not provide any evidence that the state or CALFED seeks to embrace such a forecasting tool. Overall, the authors have not sold this reviewer on their project.
Rating	Sufficient